# Two Years of AIRS hyper-spectral measurements for climate research: Sea Surface Temperature

**H. H. Aumann**

**Jet Propulsion Laboratory**
**California Institute of Technology**
**Pasadena, California 91109**

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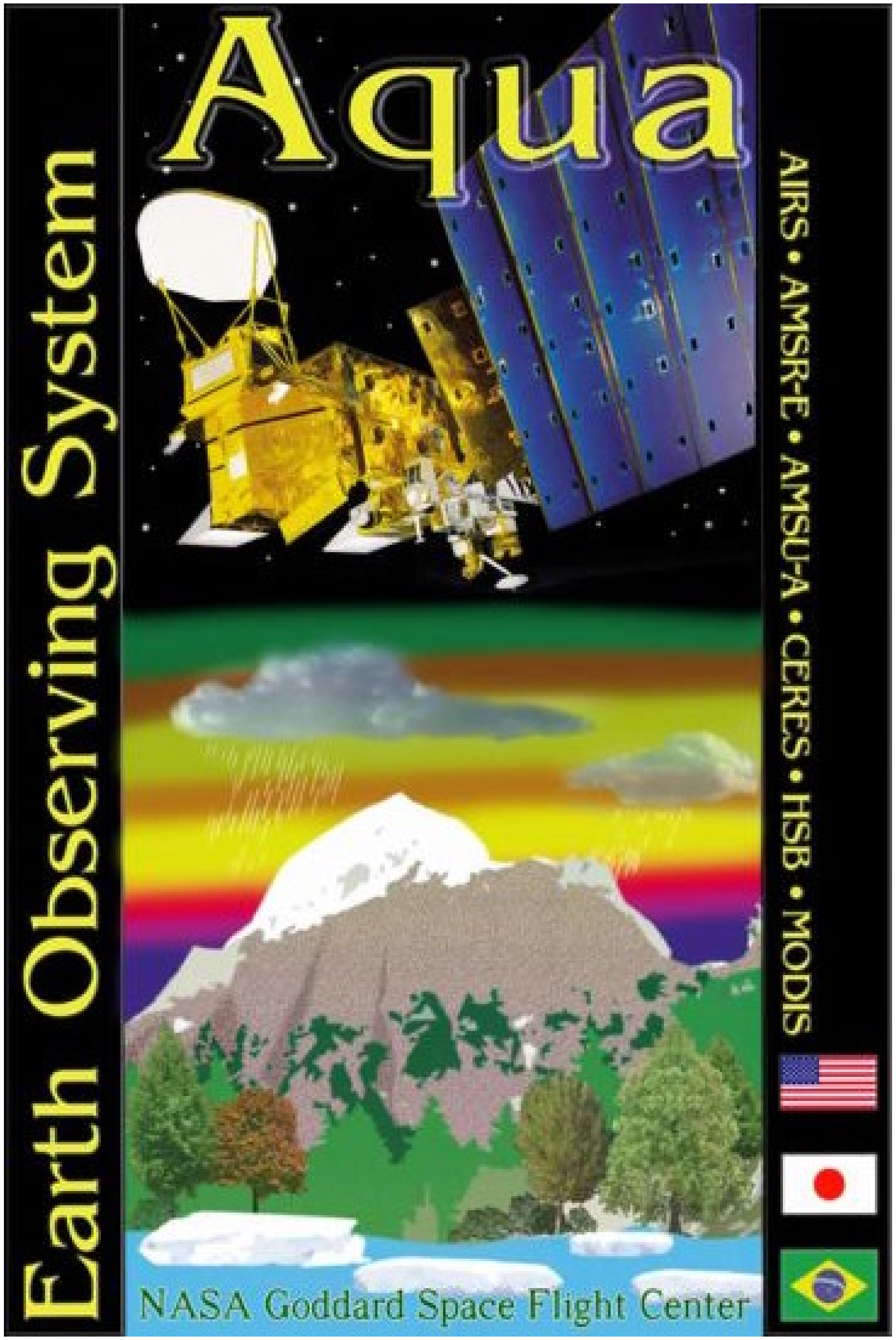
# AIRS/AMSU/HSB

| | |
|---|---|
| **Spacecraft:** | **EOS Aqua** |
| **Instruments:** | **AIRS, AMSU, HSB, MODIS, CERES, AMSR-E** |
| **Launch Date:** | **May 4, 2002** |
| **Launch Vehicle:** | **Boeing Delta II Intermediate ELV** |
| **Mission Life:** | **5 years** |
| **Team Leader:** | **Moustafa Chahine** |




**<u>AIRS Project Objectives</u>**

1. **Support Weather Forecasting**
2. **Climate Research**
3. **Atmospheric Composition and Processes**

**Global warming is observed at the 15 mK/year level from sea surface temperature (sst) measurements.**

**Warming at 5 km altitude is predicted by climate models at the faster than 15 mK/year level.**

**We use two years of ocean data to check if measurement with climate significance can be already be made with AIRS.**

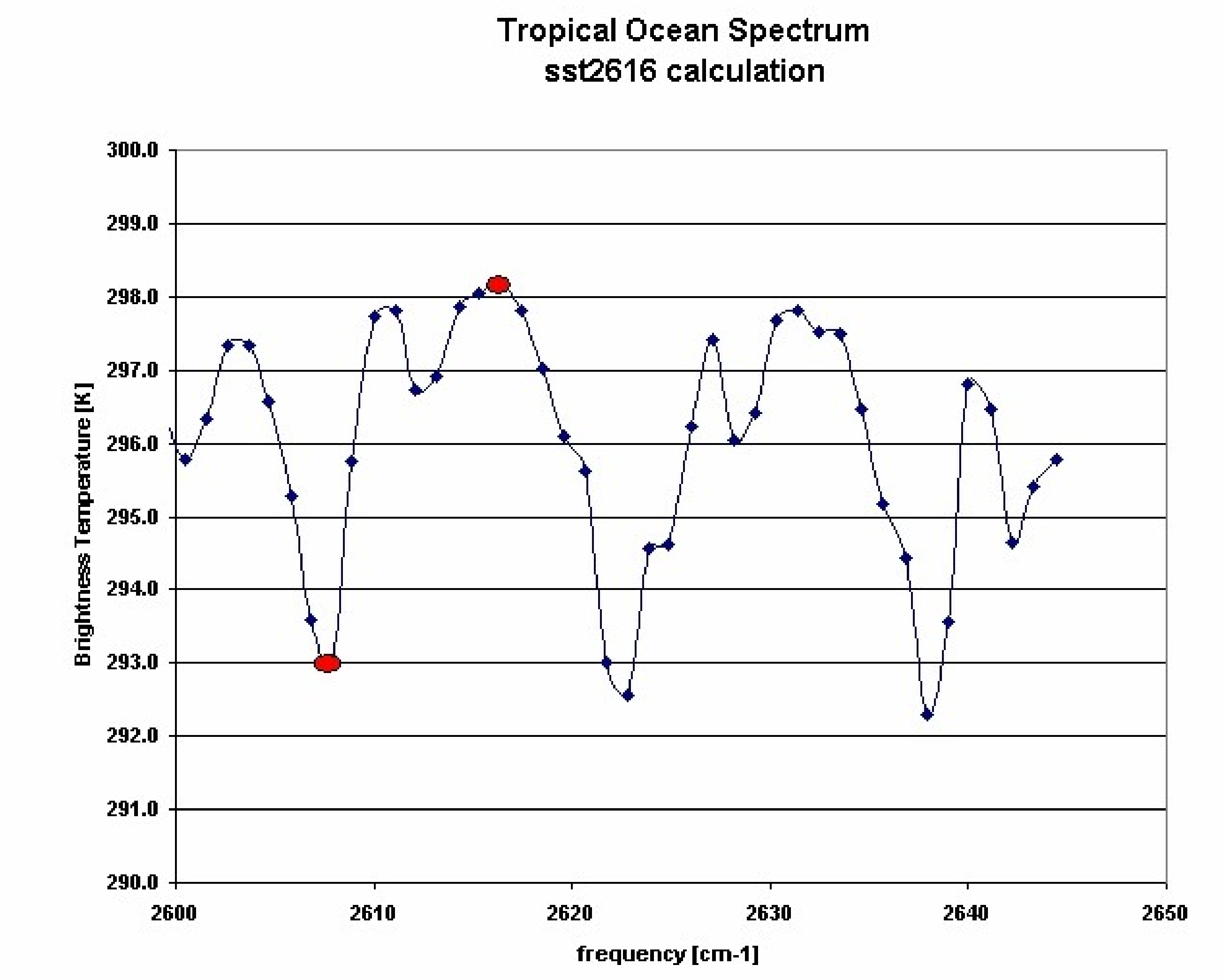
**We have used the AIRS derived sst2616 to evaluate AIRS radiometric measurement and RTG.SST stability**

**We have used the difference between 4.3 micron channels with weighting functions at 5 km altitude, but differing in co2 sensitivity to measure the 88mK/year trend expected due to the 2.2 ppmv increase in the co2 abundance.**

**We are starting to measurement temperatures at 5 km altitude to evaluate upper tropospheric moisture, temperatures and temperature gradients**

**We initially used the difference between sst2616 and rtg.sst.**

**in tropical oceans to evaluate  the AIRS radiometric stability**

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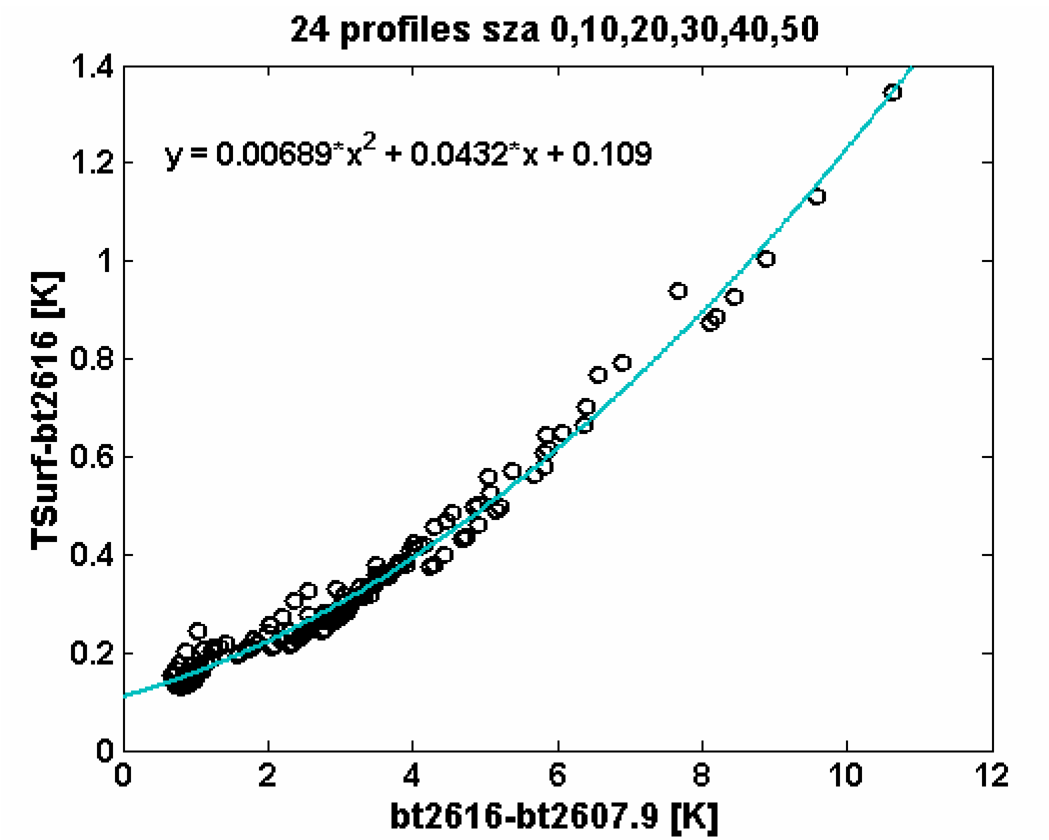
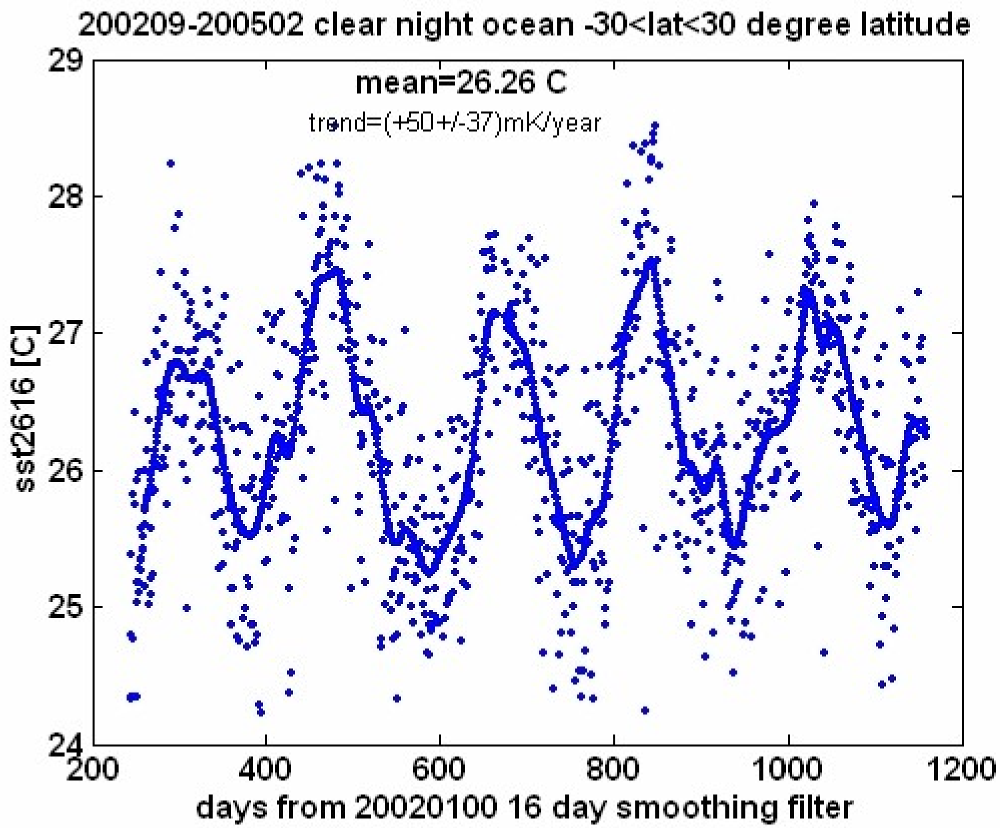
**The super window channel at 2616 cm-1 requires typically only 0.25K for water correction. The correction is supplied by the 2607 cm-1 water line**



**Shown below is the daily mean sst2616 for clear tropical ocean (+/- 30 degree latitude). The semiannual variability is dominated by the ITCZ. The scatter in the data is the variability in the temperature of clear fields on any one day**




Each point is the daily mean from about 10,000 cloud-free measurements on descending orbits

**There are several hundred ocean buoys drifting along the equator. They measure the sea surface temperature at about 1 meter below the surface with 0.1K absolute accuracy.**

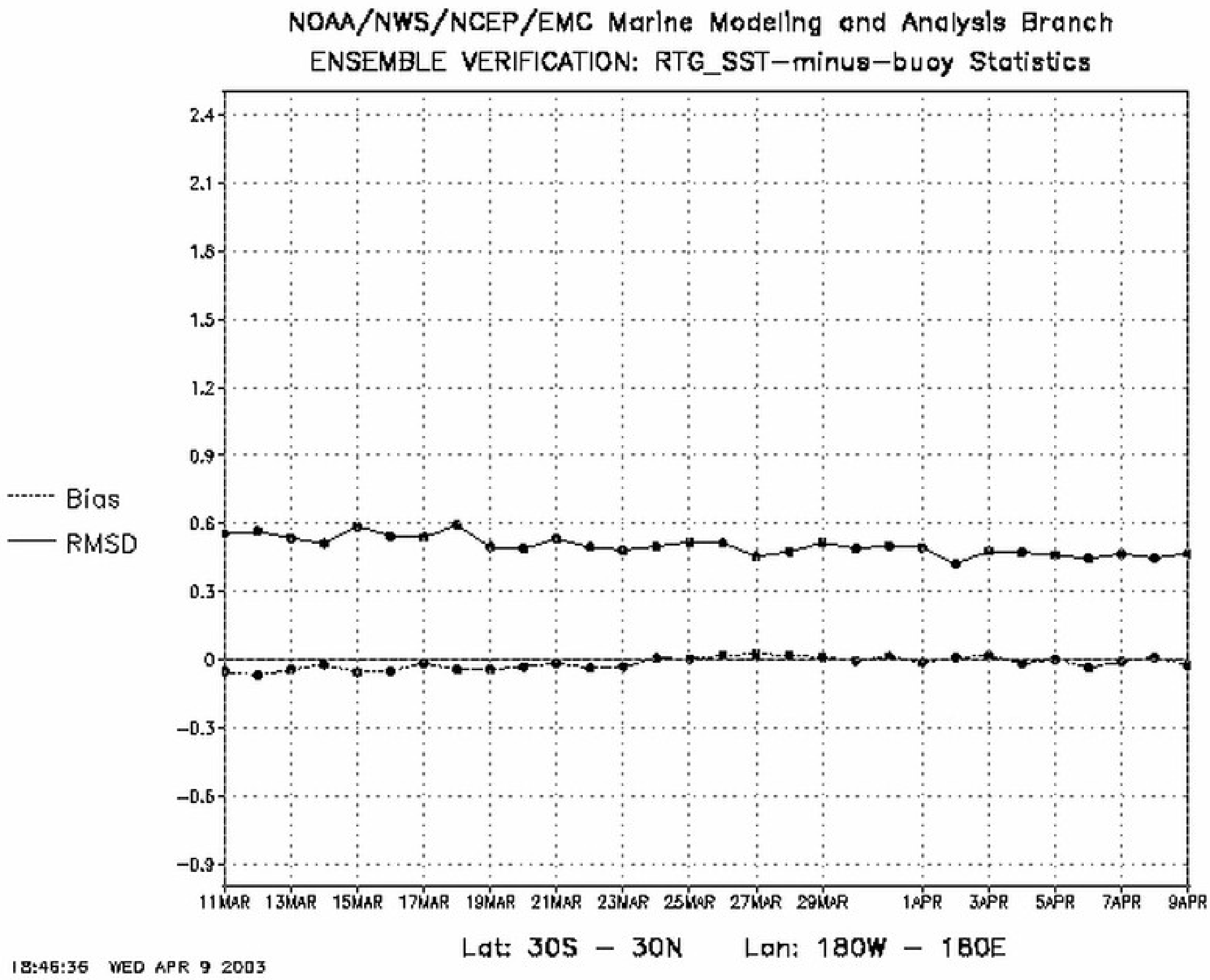
**NCEP uses these buoys to create a daily product of global sea surface temperatures by combining the buoys which satellite data (AVHRR), surface ship observations and a Global Circulation Model (GCM). The result on a one degree grid is the Reynolds SST. .Since 2000 the Real Time Global .SST, RTG.SST, is produced on a ½ degree grid**

**The global trends in the sst in the 50 year reanalysis (Kalney 1999), the analysis of the sst and now the RTG.SST form the backbone of global warming trend analysis.**

**The RTG.SST is most reliable close to the equator, where it is "tuned" to the drifting buoys.**

**It is reasonably reliable in the northern Atlantic and Pacific because of the dense shipping lanes**

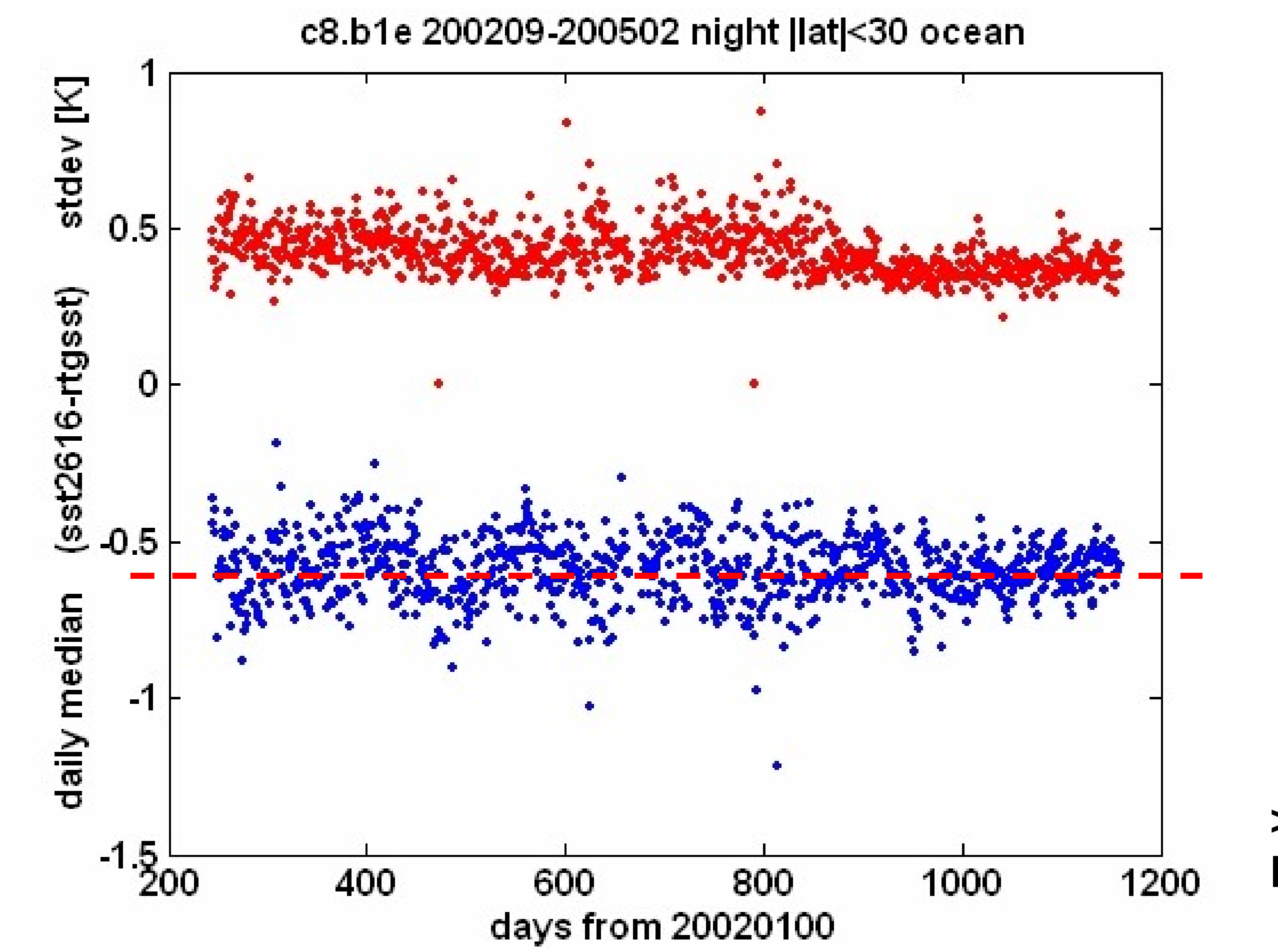
## rtg.sst tracks the floating buoys with less than 50mK bias



The NCEP provided RTG.SST on a 1/2 degree grid tracks is the most accurate for the tropical ocean temperatures since it is tuned to the drifting buoys.

If we subtract the RTG.SST from time and position matched sst2616 measurements of the tropical oceans we obtain a measure of the accuracy and stability of the AIRS radiometry.

**2.5 years of AIRS SST compared to RTGSST shows impressive measurement stability**




the rtgsst at night is 0.4K warmer than the skin measured by AIRS

>3K outlier rate is less than 1:1000

**bias = -0.589 K Slope = (-4 +/- 4) mK/year**
**trend upper limit 8mK/year**

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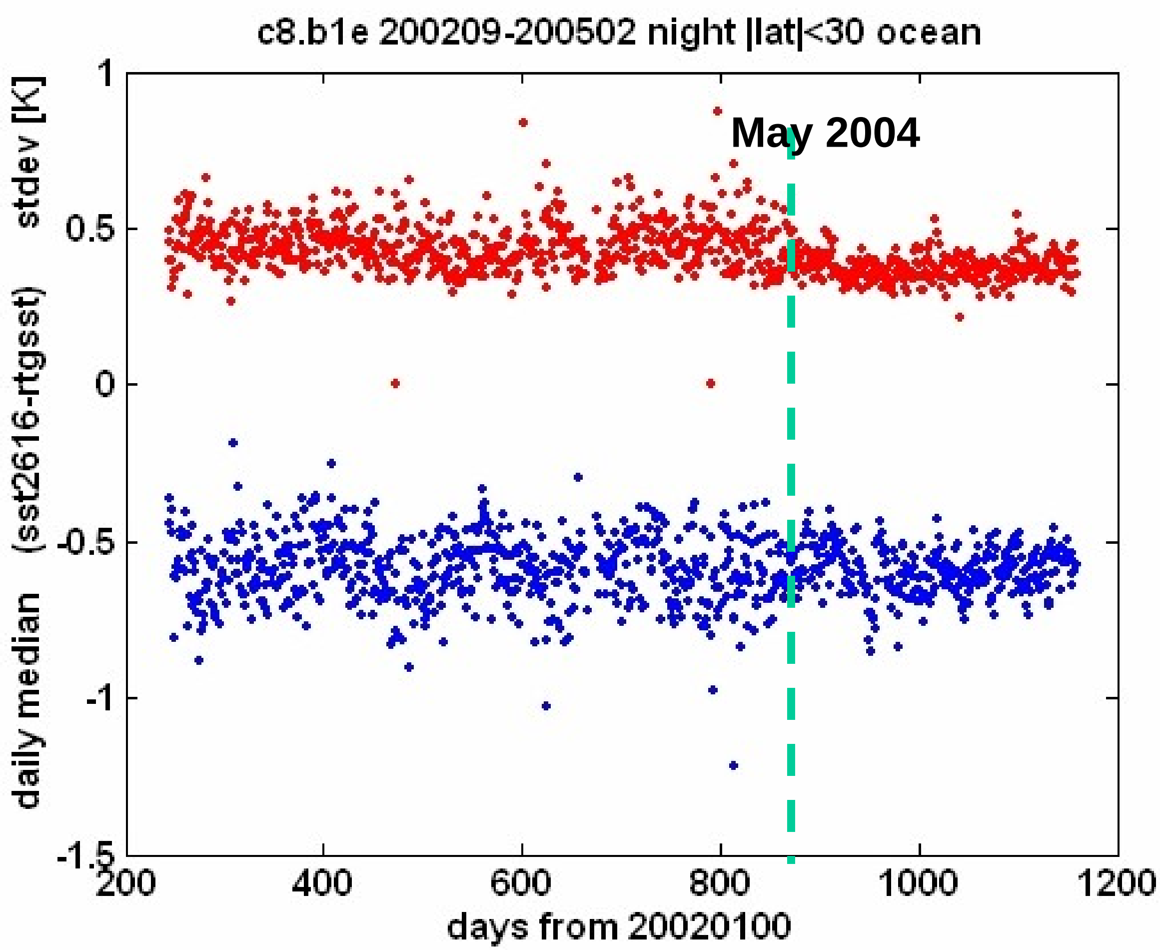
## 2.5 years of AIRS SST compared to RTGSST shows that the RTGSST is an excellent product




**For 2 years stdev(sst2616-rtgsst) = 0.413K improved to 0.370K starting in May 2004 at the same time as the switch from NOAA16 to NOAA17**

**The change in the RTG.SST prescription is not expected to change anything along the equator, because the tuning relative to the buoys.**

**The +/20 degree band around the equator covers 40% of the ocean.**

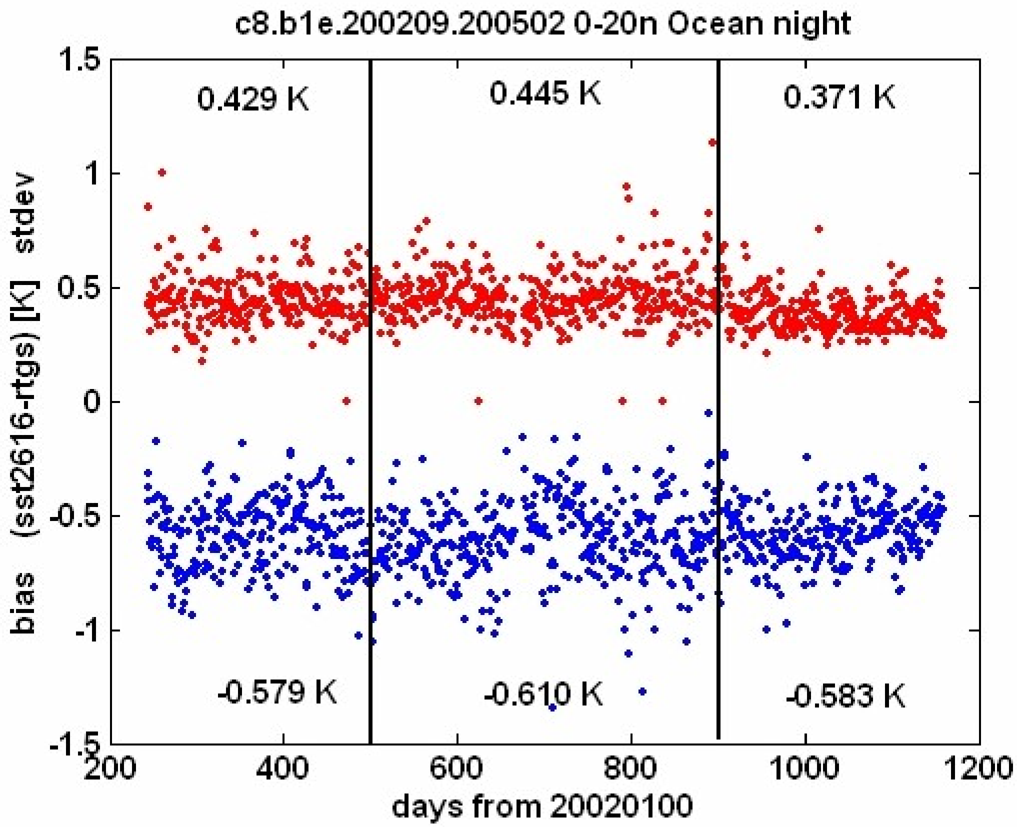
**We now use AIRS to evaluate what happens if we go to +/- 60 degree latitude. This covers about 90% of the global ocean.**

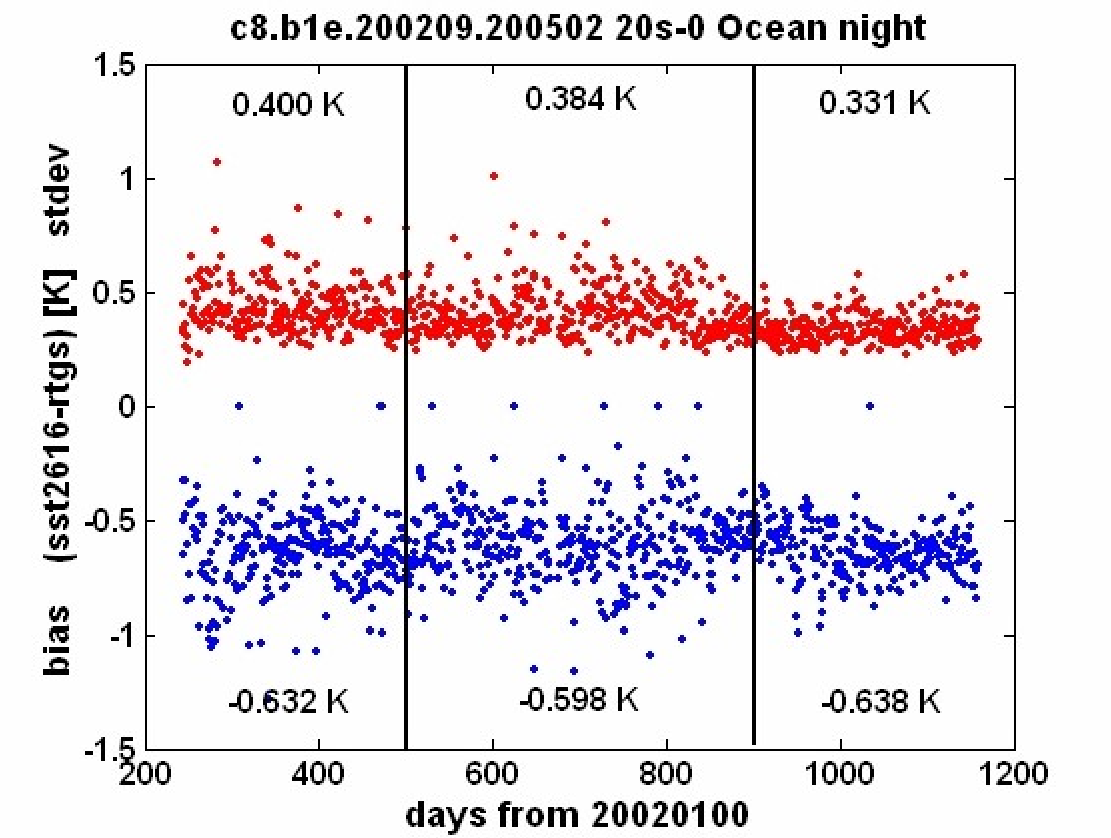
**We divide the globe into**

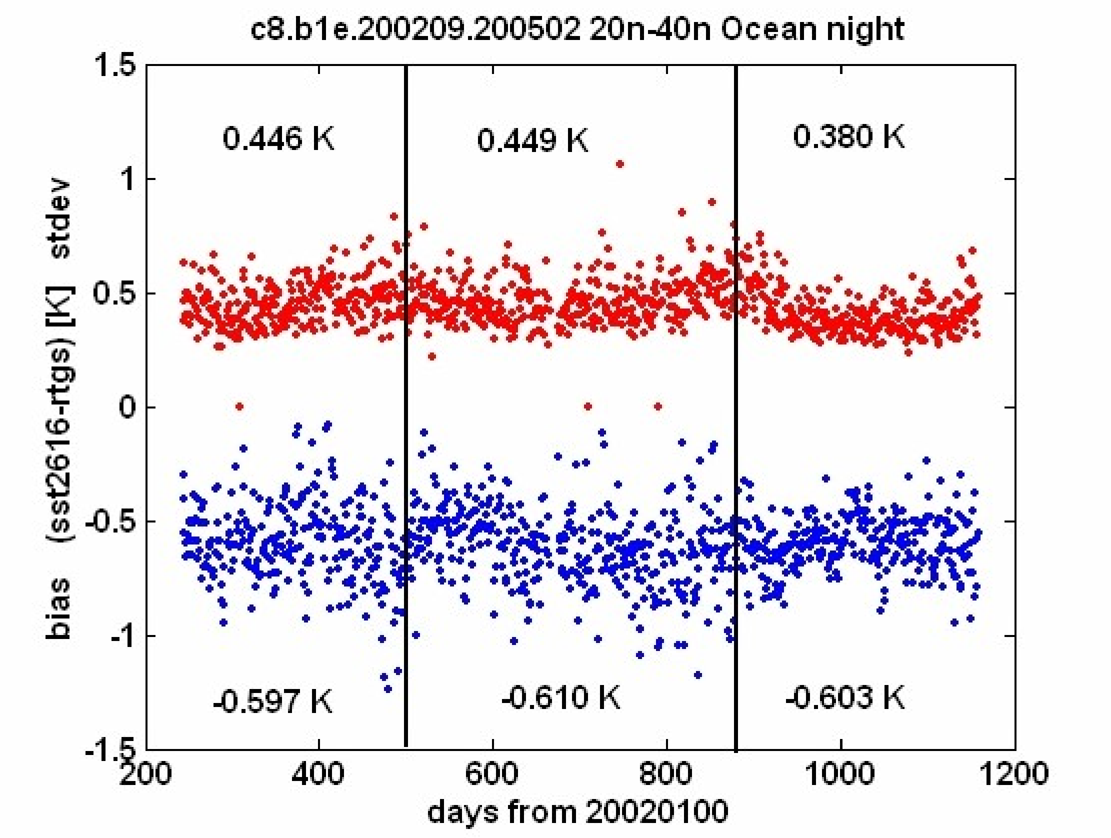
**6 latitude 20 degree wide bands centered at -50 -30 -10 +10 +30 +50**

**3 time roughly equal time slots: 2 before and one after April 2004.**

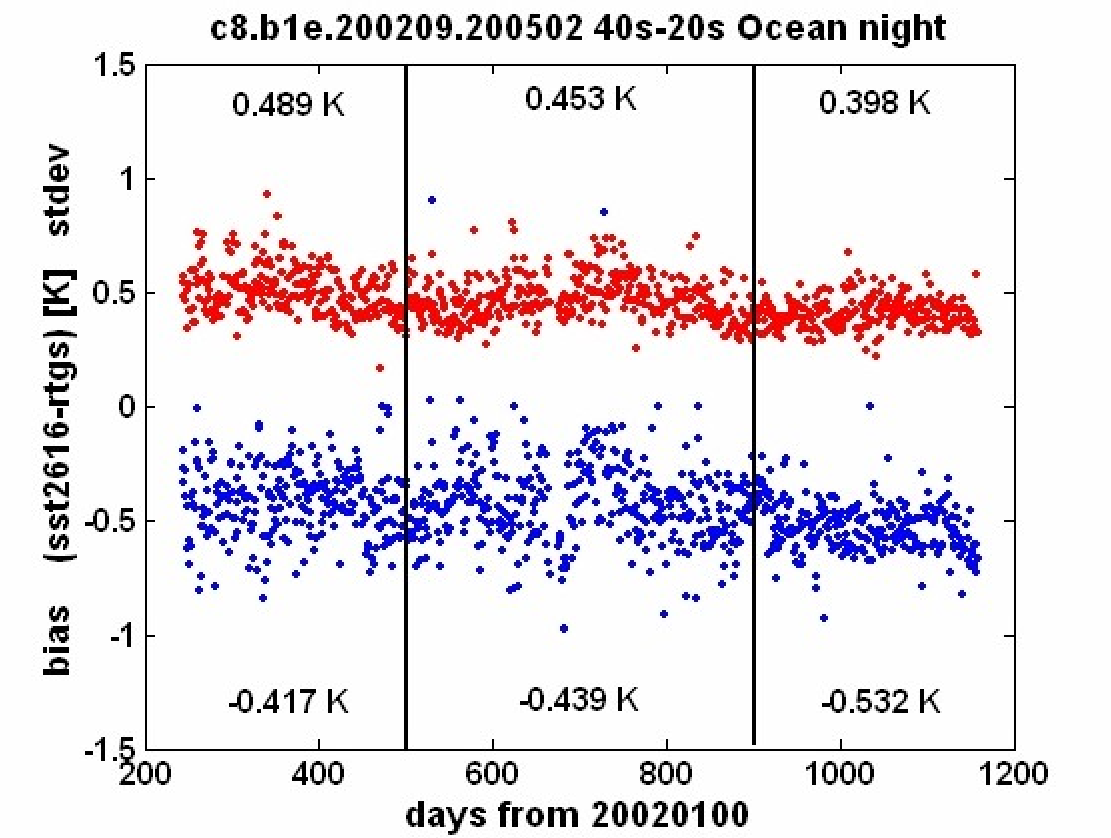
**The next six slides shows bias (blue) and stdev (red) for the six latitude bands.**

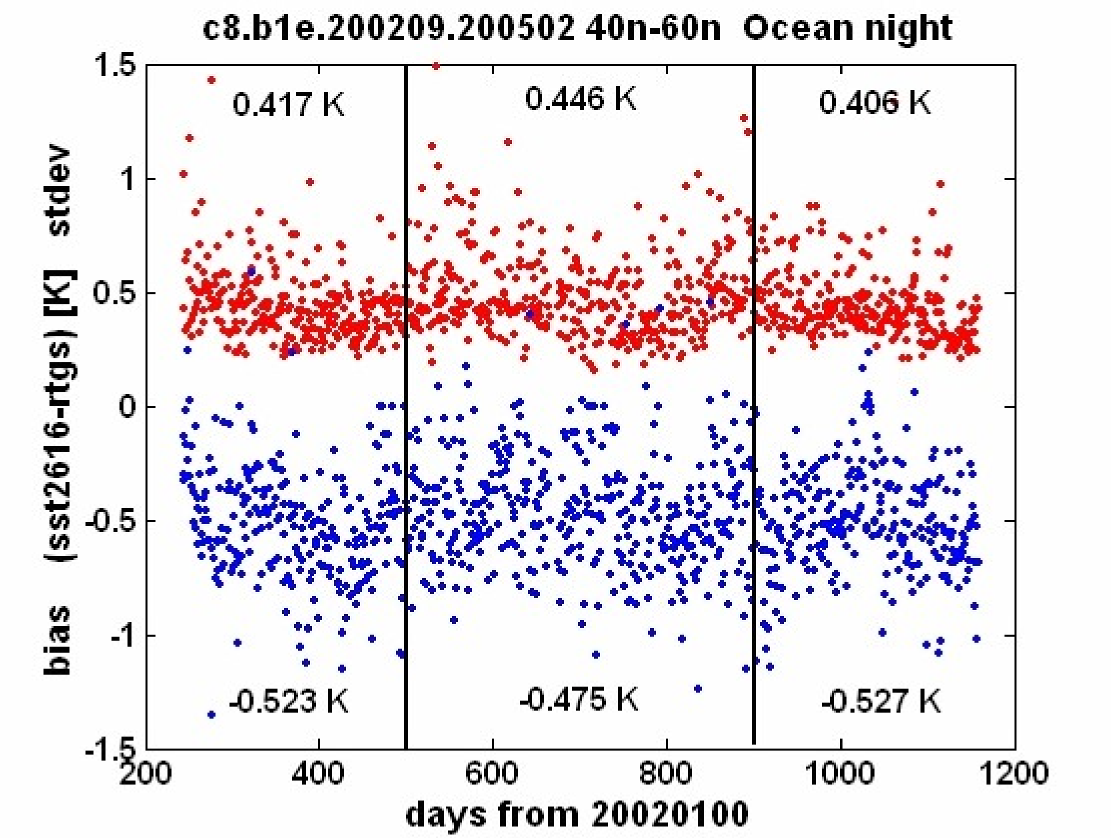

c8.b1e.200209.200502 0-20n Ocean night
bias (sst2616-rtgs) [K] stdev
days from 20020100
0.429 K
0.445 K
0.371 K
-0.579 K
-0.610 K
-0.583 K
1.5
1
0.5
0
-0.5
-1
-1.5
200
400
600
800
1000
1200

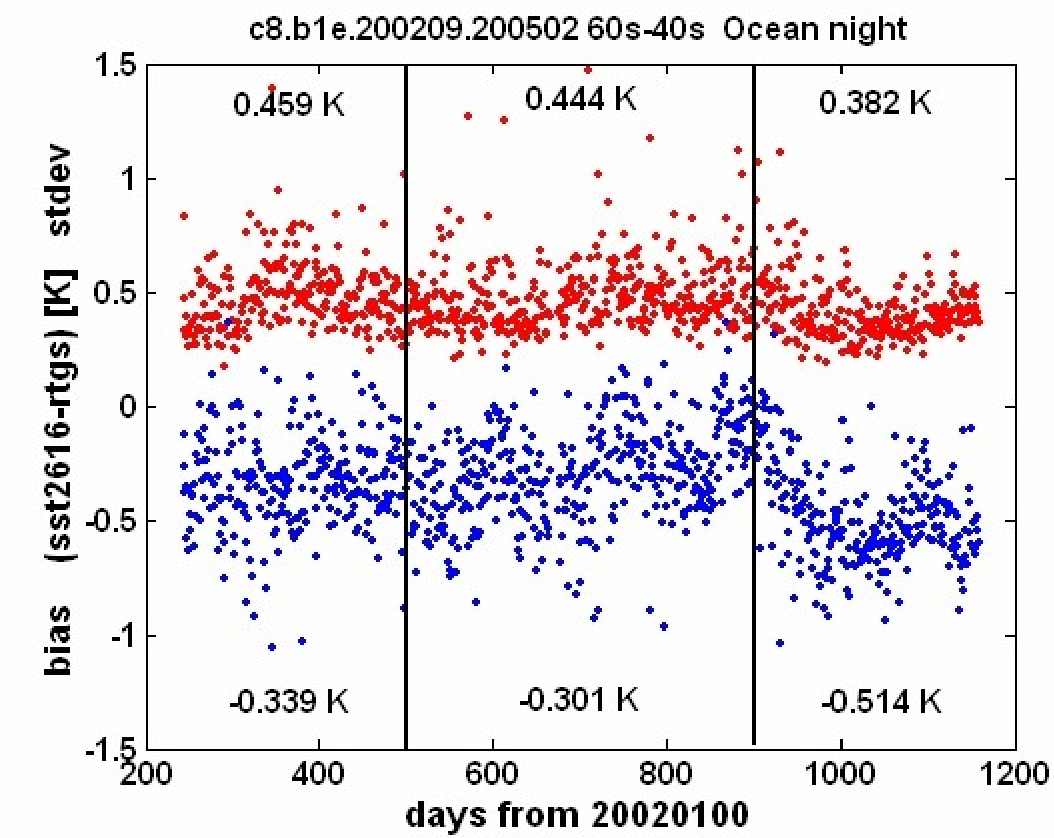

c8.b1e.200209.200502 20s-0 Ocean night
0.400 K
0.384 K
0.331 K
-0.632 K
-0.598 K
-0.638 K
bias (sst2616-rtgs) [K] stdev
days from 20020100
1.5
1
0.5
0
-0.5
-1
-1.5
200
400
600
800
1000
1200



c8.b1e.200209.200502 20n-40n Ocean night
0.446 K
0.449 K
0.380 K
-0.597 K
-0.610 K
-0.603 K
bias (sst2616-rtgs) [K] stdev
days from 20020100


c8.b1e.200209.200502 40s-20s Ocean night
0.489 K
0.453 K
0.398 K
-0.417 K
-0.439 K
-0.532 K
bias (sst2616-rtgs) [K] stdev
days from 20020100
1.5
1
0.5
0
-0.5
-1
-1.5
200
400
600
800
1000
1200


c8.b1e.200209.200502 40n-60n Ocean night
bias (sst2616-rtgs) [K] stdev
days from 20020100
0.417 K
0.446 K
0.406 K
-0.523 K
-0.475 K
-0.527 K
1.5
1
0.5
0
-0.5
-1
-1.5
200
400
600
800
1000
1200



c8.b1e.200209.200502 60s-40s Ocean night
0.459 K
0.444 K
0.382 K
-0.339 K
-0.301 K
-0.514 K
bias (sst2616-rtgs) [K] stdev
days from 20020100
1.5
1
0.5
0
-0.5
-1
-1.5
200
400
600
800
1000
1200

**Stdev(sst2616-rtgsst) [K] for six latitude bands and three time slices between September 2002 and February 2005**

| | 200-500 | 500-900 | 900-1200 |
|---|---|---|---|
| 40n-60n | 0.417 | 0.446 | 0.406 |
| 20n-40n | 0.446 | 0.449 | 0.380 |
| 0-20n | 0.429 | 0.445 | 0.371 |
| 20s-0 | 0.400 | 0.384 | 0.331 |
| 40s-20s | 0.489 | 0.453 | 0.398 |
| 60s-40s | 0.459 | 0.444 | 0.382 |

**The decrease in the standard deviation starting in May 2004 shows up in all six latitude zones**

**mean (sst2616-rtgsst) [K] for six latitude bands and three time slices between September 2002 and February 2005**

| | 200-500 | 500-900 | 900-1200 |
|---|---|---|---|
| 40n-60n | -0.523 | -0.475 | -0.527 |
| 20n-40n | -0.597 | -0.610 | -0.603 |
| 0-20n | -0.579 | -0.610 | -0.583 |
| 20s-0 | -0.632 | -0.598 | -0.638 |
| 40s-20s | -0.417 | -0.439 | -0.532 |
| 60s-40s | -0.339 | -0.301 | -0.514 |

**The bias in the four zones above 20s is stable for the all three time periods**

**mean (sst2616-rtgsst) [K] for six latitude bands and three time slices between September 2002 and February 2005**

| latitude bands | 200-500 days since 20020100 | 500-900 | 900-1200 |
|---|---|---|---|
| 40n-60n | -0.523 | -0.475 | -0.527 |
| 20n-40n | -0.597 | -0.610 | -0.603 |
| 0-20n | -0.579 | -0.610 | -0.583 |
| 20s-0 | -0.632 | -0.598 | -0.638 |
| 40s-20s | -0.417 | -0.439 | -0.532 |
| 60s-40s | -0.339 | -0.301 | -0.514 |

**Since the bias values for all six latitude bands are consistent since May 2004 we conclude that the 60s-40s RTG.SST was about 0.2K too cold before then.**

**Since the bias values for the six latitude zones are consistent since May 2004, we conclude that the RTG.SST was about 200 mK too cold before then.**

**If this is ignored in the trend analysis, it could be interpreted as a sudden 200 mK warming of the southern ocean**

**The southern oceans (below latitude -20 degree) constitute 36% of the global oceans**
**If this is ignored it could be interpreted as a sudden 200 mK*0.36= 70mK global warming**

**In view of the 15 mK/year global warming of the oceans established by the 50 year reanalysis, a sudden 200mK southern ocean or a global 70 mK warming due to an algorithmic change is serious.**

**My reading is that the RTGSST has been too cold for the past two years.**
**The breakup of the Antarctic ice is consistent with the warmer sst.**

**Next step: How does the ECMWF sst work out?**

**Stand by for more on this subject.**

**Thanks for your attention**